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Computer Assisted Teaching of Cardiac Arrhythmias*

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A computer program has been designed to assist in the teaching of cardiac arrhythmias at various levels of training. The basic structure and some features of the program are described as well as the advantages derived from its use.

There is little question about the fact that one of the weakest points in the teaching of clinical cardiology to medical students, house staff and even fellows or trainees is that of the cardiac arrhythmias. There are several salient features in this problem:

(1) The teaching of arrhythmias is time consuming for the instructor. Many cases require lengthy analysis of multiple parameters (i.e., interval measurements, time-course (sometimes over a period of days), action of different procedures, special leads and many others). However, in our experience, personal tutoring, though not indispensable, definitely shortens the time required to become proficient in the art of diagnosing complex cardiac arrhythmias.

(2) The data available to the cardiologist has multiplied in recent years. The rapid spread of the concepts of intensive coronary care brought about the development of sophisticated around-the-clock electrocardiographic monitoring equipment so that transient arrhythmias that heretofore went unnoticed and even unsuspected are now recorded for detailed analysis.

(3) Basic electrophysiologic research in both impulse formation and impulse conduction mechanisms, as well as recent studies on ultrastructure of the myocardial fiber, offer the clinician the opportunity of correlating his own bedside findings with those of the research laboratory to an extent not possible in any other field of medicine today.

(4) The increasing use of artificial pacemakers makes precision in the

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diagnosis of arrhythmias absolutely mandatory. The vast possibilities of this method of research and treatment (which consists essentially in taking over control of the patient's cardiac rhythm) and the variety of devices available (continuous, automatic, fixed-rate, demand, paired-pulse, coupled, atrio-synchronized, etc.), each one with its own precise and limited indications, makes a thorough knowledge of cardiac arrhythmias indispensable. The same principles apply, perhaps to a different extent, to procedures such as cardioversion and to the use of new forms of drug therapy.

The computer-based teaching program in arrhythmias described in this article is designed to provide the user with up-to-date information by incorporating recent advances in the subject and newly accepted concepts. Even though the nomenclature used may occasionally appear unfamiliar to the user and some electrocardiographic patterns of impulse formation or conduction presented in the program may be infrequent in clinical practice, the approach here presented is indicated in view of the above stated facts.

The digital computer has already proved to be an excellent teaching aid in clinical cardiology.[1] The necessary instrumentation for this arrhythmia teaching program consists of a medium-scale, general purpose electronic digital computer with time-sharing and multiprogramming features* operating under control of the MEDLAB monitor, and a remote station which includes a memory oscilloscope,† a numbered keyboard and labeled switches. This system has been extensively described elsewhere.[2]

The teaching session begins at the time the user chooses and lasts as long as he desires. He sits comfortably in front of his station and calls the program into the computer by dialing the appropriate code and pressing an interrupt button (Fig. 1). When this is done, an electrocardiogram randomly selected by the computer from a library of arrhythmias is displayed on the scope along with a message containing information about the tracing such as heart rate, identification of lead shown, P–R and/or QRS intervals, P wave polarities in leads other than the one displayed or other information that may apply to the case being presented (Fig. 2). At this point, control automatically transfers to the monitor program and the computer is free to serve other stations. When the user presses the SEND button to interrupt the computer, the same tracing is displayed again, now with a message giving a series of numbered diagnostic options from which the user chooses one by pressing the corresponding number (Fig. 3). If the right diagnosis is made by the user, a message on the scope will appear confirming his correct choice and asking him to press the interrupt in order to proceed to the next case. If an incorrect answer is given, the corresponding tracing and/or

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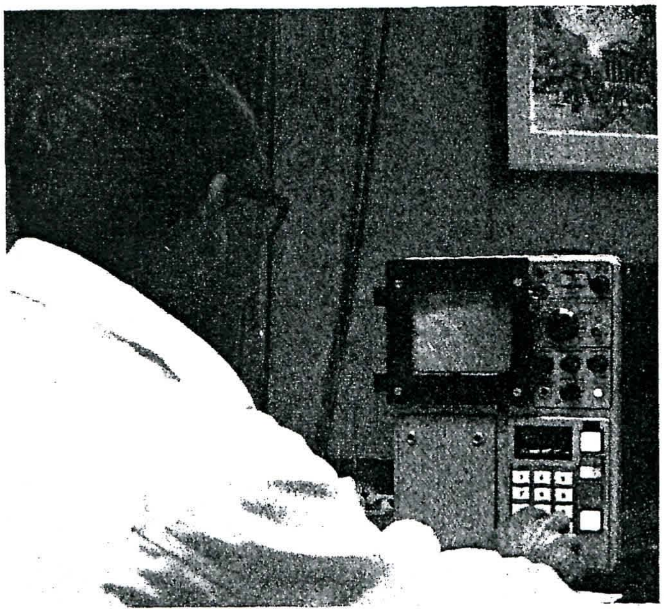

FIG. 1. Remote station

a message pointing out the differential diagnostic features between the case being considered and the incorrect diagnosis selected will be displayed. When the computer is interrupted again after the tracing and the message have been studied by the user, the program will present the original electrocardiogram and informa-

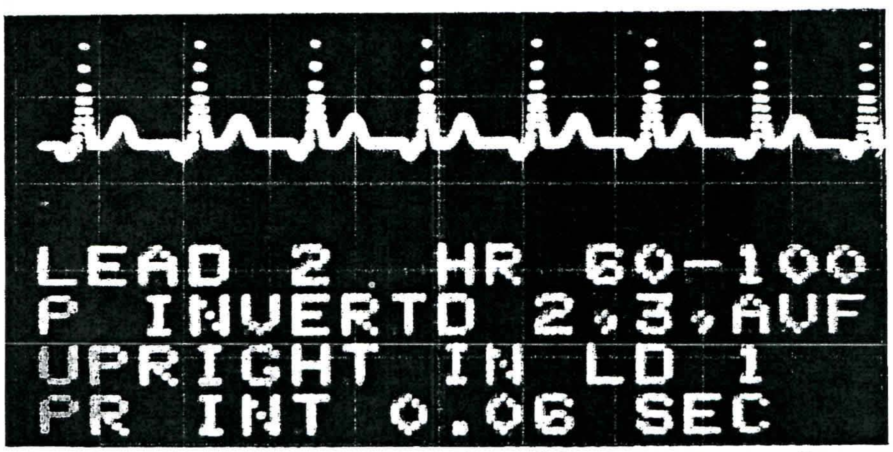

FIG. 2. Tracing and information message displayed by the computer on the remote station scope.

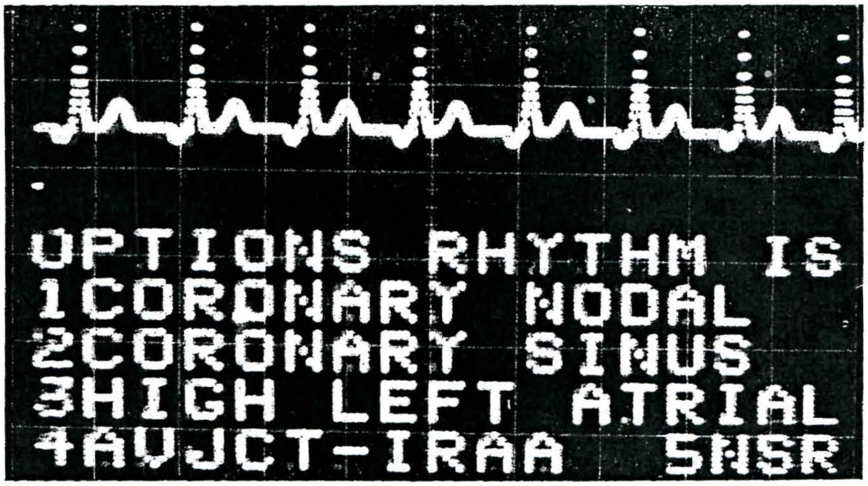

FIG. 3. Diagnostic options for the same tracing as in Fig. 2. AVJCT-IRAA is the abbreviation used for atrioventricular junctional with initial retrograde atrial activation.

tion message. He can now review the tracing, compare the information given to him when he selected the wrong diagnostic option with that given for the case being presented and try again. Fig. 4 illustrates the basic structure of this section of the program.

This method of teaching has several obvious advantages. There is no pressure on the user for time. The computer behaves as an ever-present teacher and the user is not aware of the fact that other stations are being serviced while he runs the program. The answers flash on the scope at the touch of his finger and he seems to have the full and undivided attention of the computer.

The program keeps a running score which can be displayed by the user or his instructor after all the cases have been presented. The user's score is displayed on request as the percent of choices which were in error.

After running through all the cases, which are presented only once in random order, the user is given the option of ending the program or reviewing the tracings in the library. This can be done in the order desired by the user with each tracing displayed on the scope as many times as desired and for as long as necessary. All graphs are shown with the corresponding diagnosis and, in some cases, with a message pointing out features of interest.

An additional feature of the program allows an instructor to display on another adjacent scope any tracing in the library while the program is in use without interfering with the student's run. This is particularly useful when working simultaneously with several students, or if personal instruction is being given to a first-time user of the program.

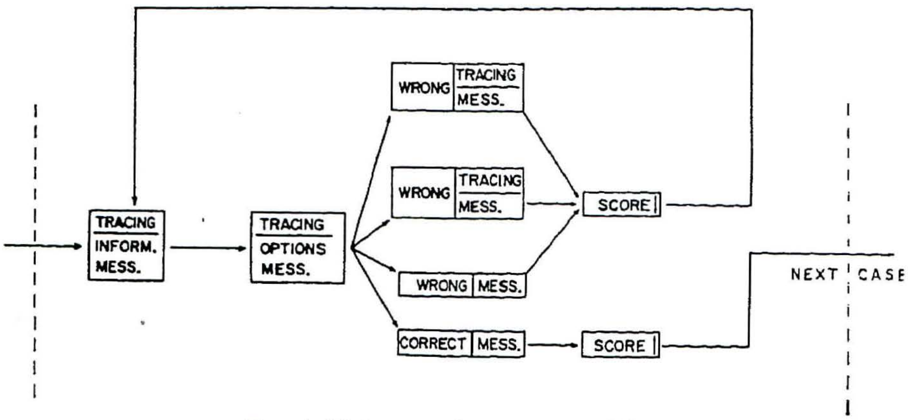

FIG. 4. Main control program module.

In order to facilitate instruction for those who have a basic knowledge of the fundamentals of electrocardiography but are not familiar with arrhythmias, a booklet classifying and defining the rhythms used in the program has been prepared. In addition, this booklet presents to the student the salient differential diagnostic features of each case and provides him with a list of specific bibliographic references for most of the abnormal rhythms.

A Fortran program generates electrocardiographic patterns by combining different wave elements (P wave, QRS, etc.) which are entered in numerical form via a card reader. The tracings thus formed may vary in rate, P wave and QRS morphology and polarity, T wave configuration, P-R, S-T and T-P segment length, P-QRS relationship, etc., according to the pattern established by the programmer. Any of the above parameters can be easily modified if necessary and additional cases can be incorporated in the program using the same wave components. The tracings are stored on disc with each case occupying 16 sectors of 64 24-bit words each. Another Fortran program reads the information and option messages from cards and stores each message on one sector of the disc.

The main control program, written in assembly language, calls the tracings and the accompanying messages from disc storage into magnetic core as required by the case being presented or the diagnostic options selected. A resident subroutine then displays the tracing and message on the scope when the user presses the manual interrupt. The low-order bits of the computer's real-time clock are sampled to randomly select the order in which the cases are presented. Since the disc is accessed for retrieval of individual tracings or messages as they are needed, the core storage requirements of the program are relatively small, making it economical to run in a multiprogram environment such as MEDLAB. A modular form has been followed in both Fortran programs and in the basic assembly language main control part to facilitate changes in the cases when required by the teaching schedules. Thus, individual options or entire cases can be deleted or added without substantial modifications. (In Fig. 4 a module of the control program is shown between the dotted lines.)

The program can be converted from a primer on arrhythmias into a self-contained advanced teaching course simply by increasing the complexity or diagnostic difficulties of the cases included. In addition, it is possible to divide the library of cases into several parts if simultaneous teaching at various levels is desired or it may be updated when new developments in the field take place.

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